United States Patent [19]

Toukmanian

[11] **3,904,069**

[45] **Sept. 9, 1975**

[54] **CONTAINER**

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[73] Assignee: **American Can Company,** Greenwich, Conn.

[22] Filed: **Oct. 25, 1973**

[21] Appl. No.: **409,734**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 222,050, Jan. 31, 1972, abandoned.

[52] **U.S. Cl.** **220/66;** 220/70

[51] **Int. Cl.** **B65d 7/42**

[58] **Field of Search** .... 229/2.5; 150/.5; 220/70, 220/66, 67, DIG. 22; 215/1 C; 113/120 H, 120 S

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Primary Examiner—George E. Lowrance
Assistant Examiner—Allan N. Shoap
Attorney, Agent, or Firm—Robert P. Auber; James W. Bock; George P. Ziehmer

[57] **ABSTRACT**

A cylindrical metal can body for pressurized products having integral side and bottom walls is constructed such that the bottom wall includes a centrally disposed circular depression or dimple therein, the base area of the depression being less than approximately 60 percent and greater than approximately 15 percent of the total area of the bottom wall. This bottom wall structure permits the can to expand in height when subjected to internal pressure, while preserving stability when placed in an upright standing position since the bottom is uniformly deformed by the internal pressure into a shape in which the circular rim of the depression forms a suitable stable base on which the can sits.

30 Claims, 21 Drawing Figures

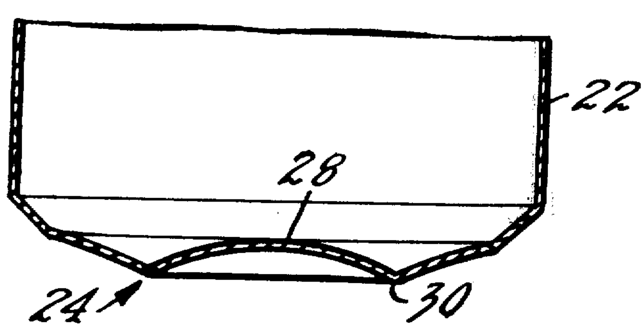


FIG. 1

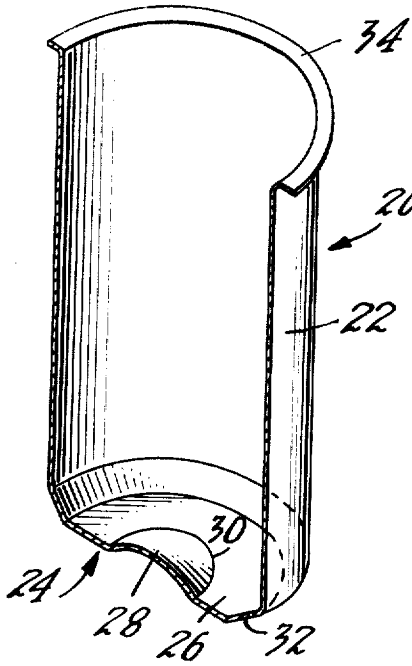


FIG. 2

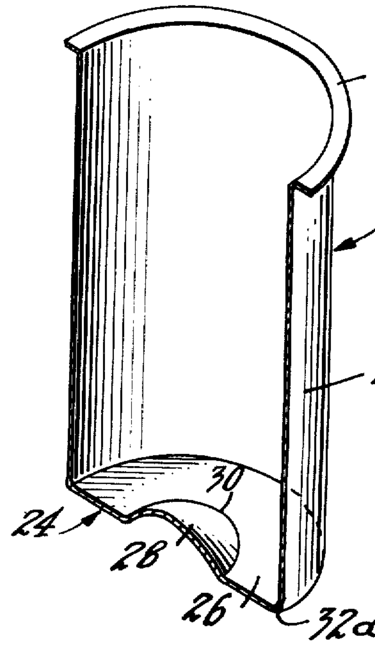


FIG. 3

PRIOR ART

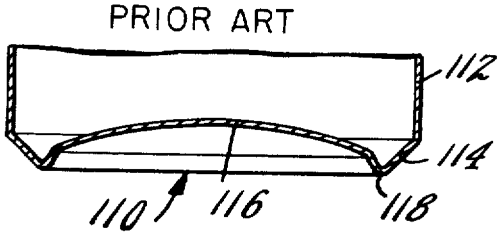


FIG. 4

PRIOR ART

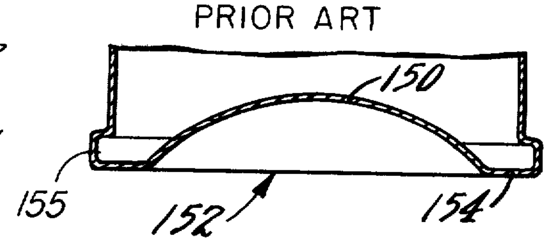


FIG. 5

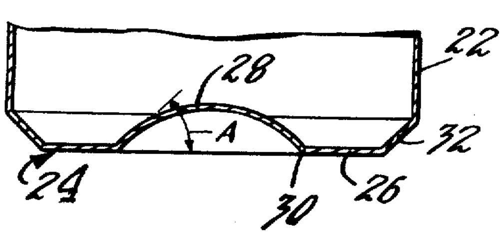


FIG. 6

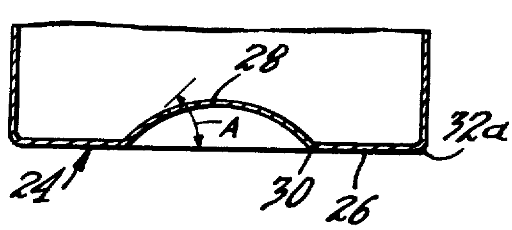


FIG. 7

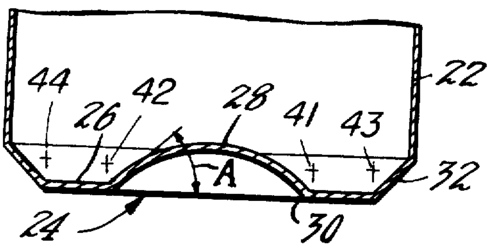


FIG. 8

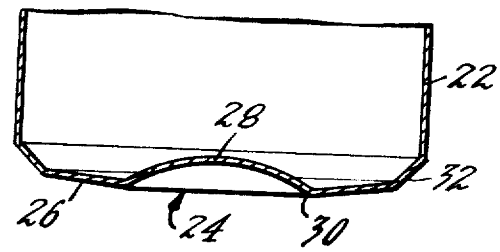


FIG. 9

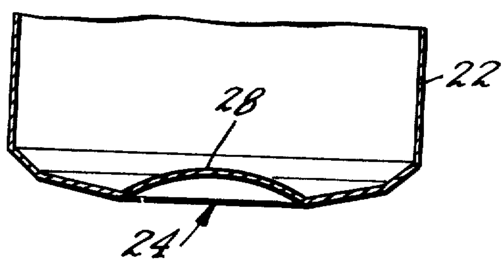


FIG. 10

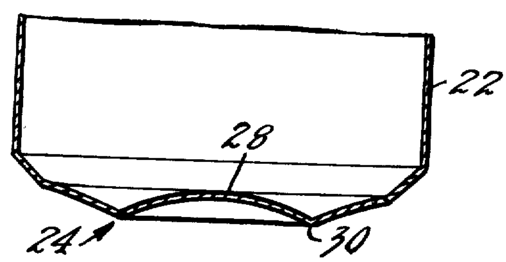


FIG. 12

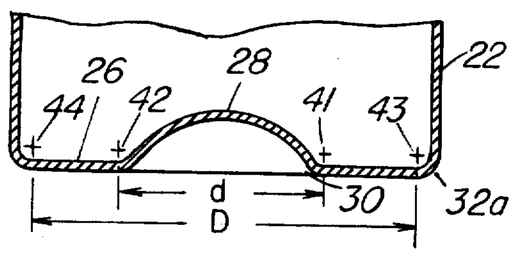
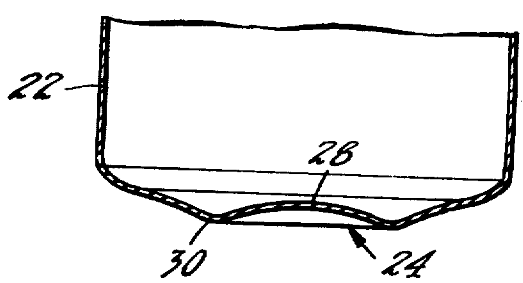


FIG. 11



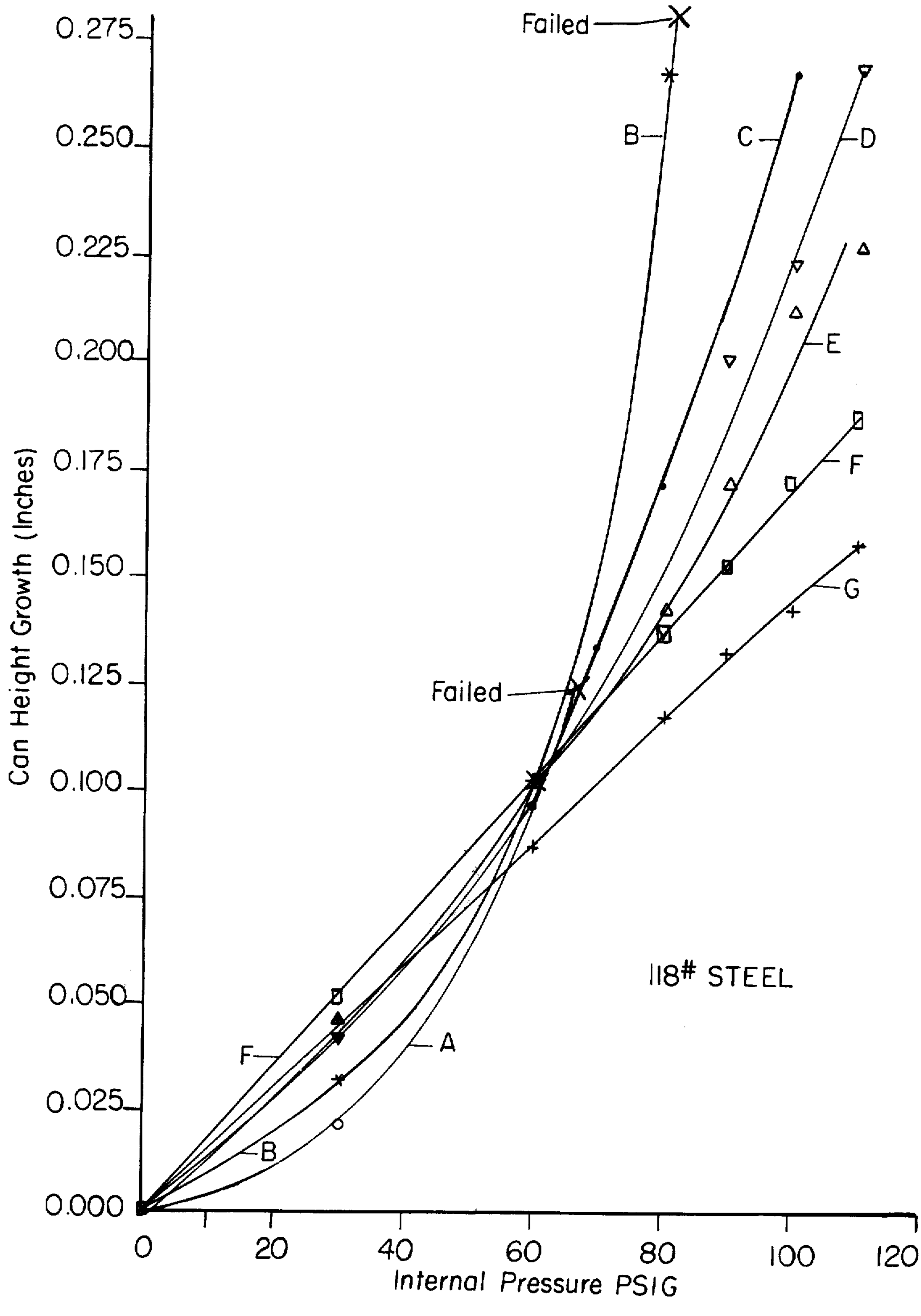

Failed
Failed
B
C
D
E
F
G
A
F
B
118# STEEL
Can Height Growth (Inches)
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0
20
40
60
80
100
120
Internal Pressure PSIG

FIG. 13

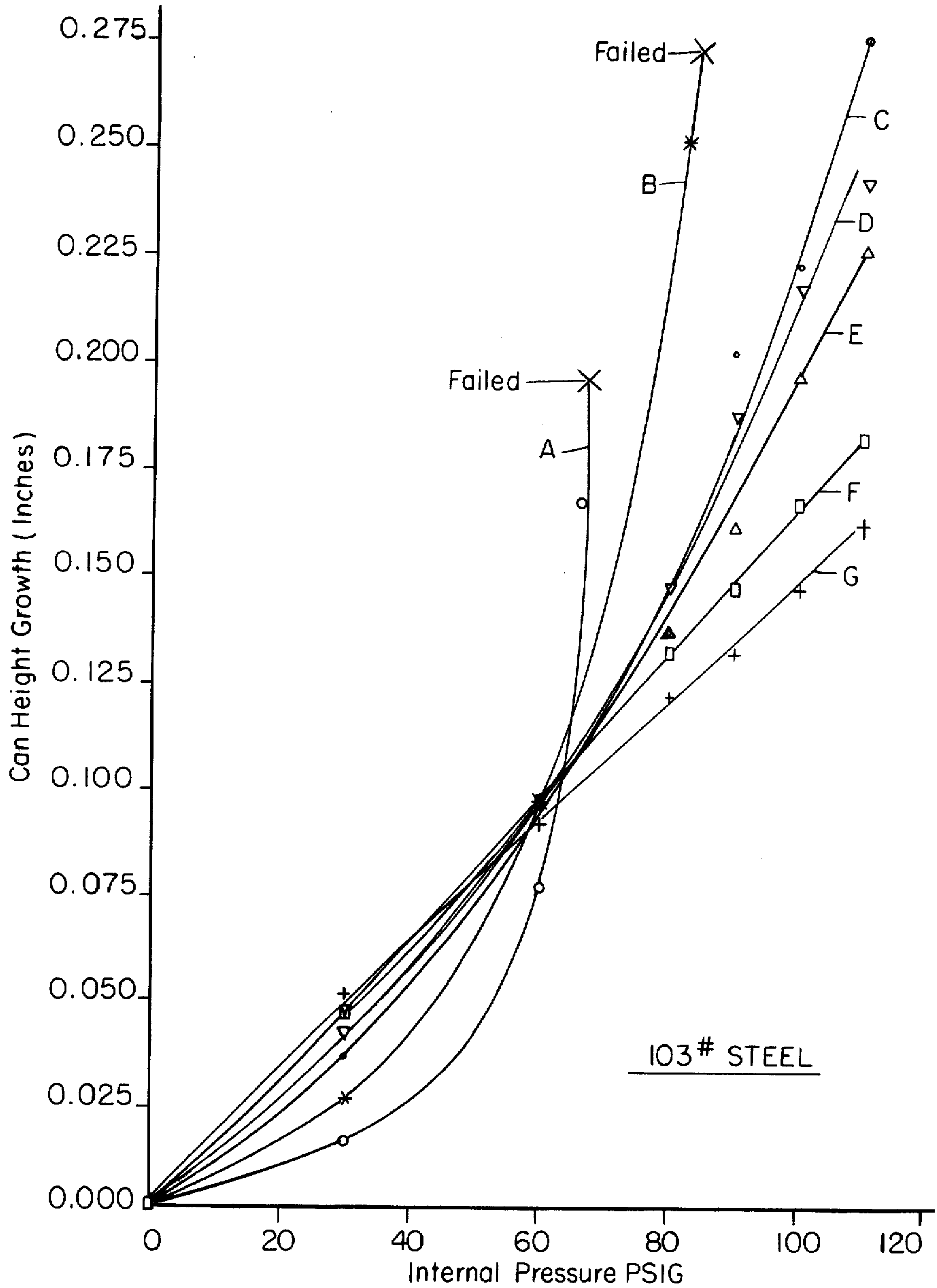

0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Can Height Growth (Inches)
Failed
Failed
A
B
C
D
E
F
G
103# STEEL
0
20
40
60
80
100
120
Internal Pressure PSIG

FIG. 14

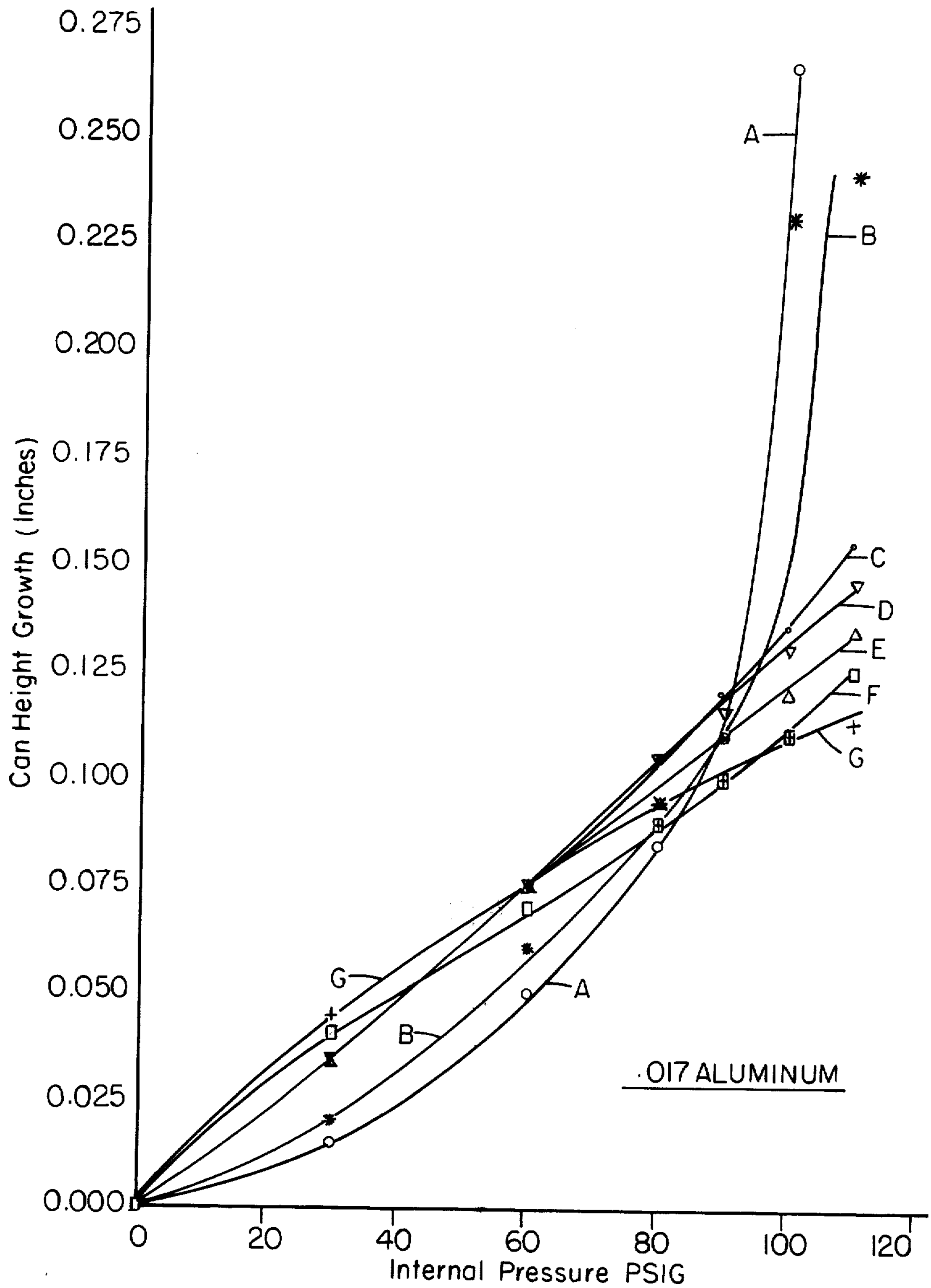

Can Height Growth (Inches)
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0
20
40
60
80
100
120
Internal Pressure PSIG
A
B
C
D
E
F
G
.017 ALUMINUM

FIG. 15

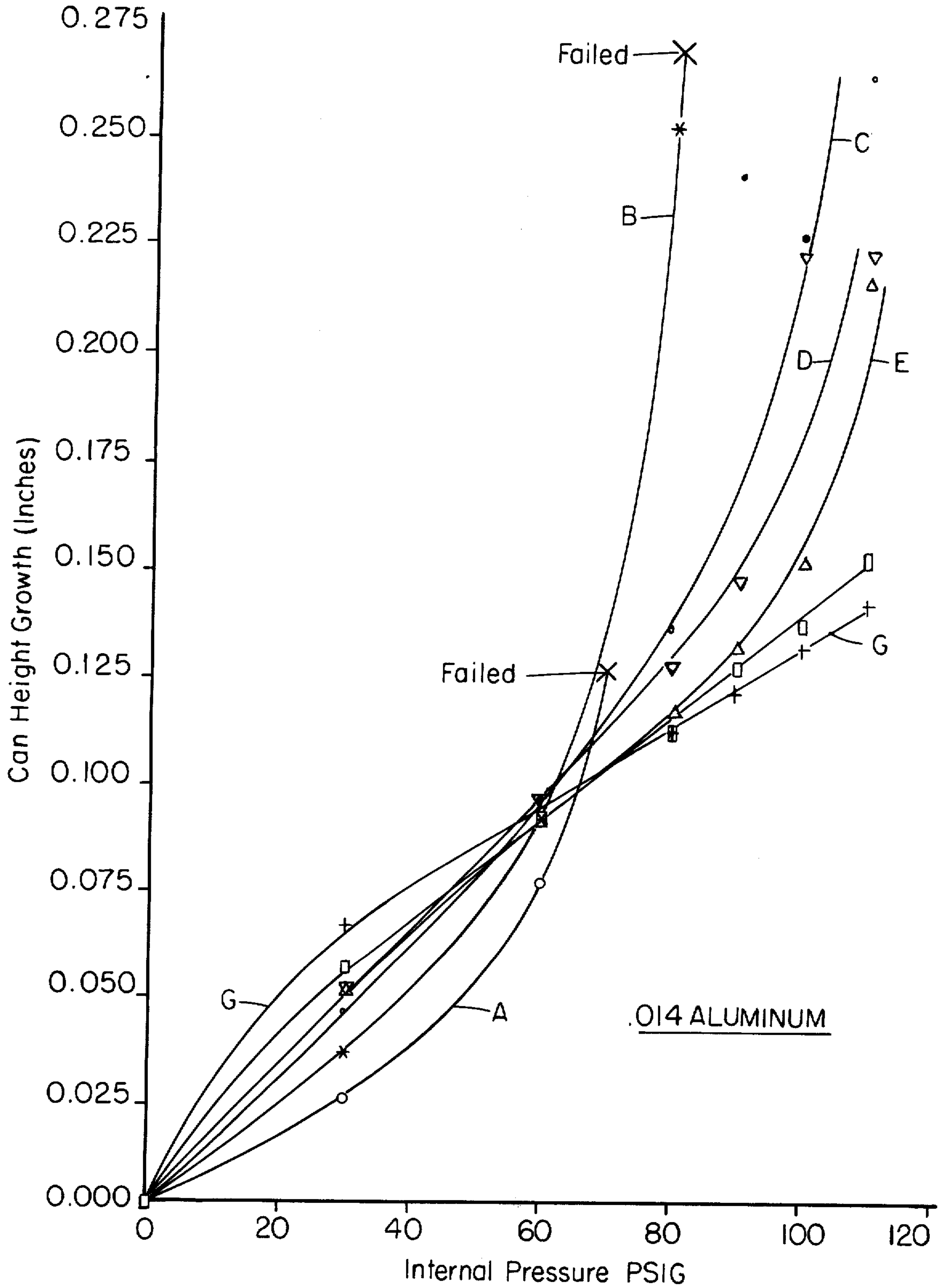

Can Height Growth (Inches)
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0
20
40
60
80
100
120
Internal Pressure PSIG
Failed
Failed
A
B
C
D
E
G
G
.014 ALUMINUM

FIG. 16

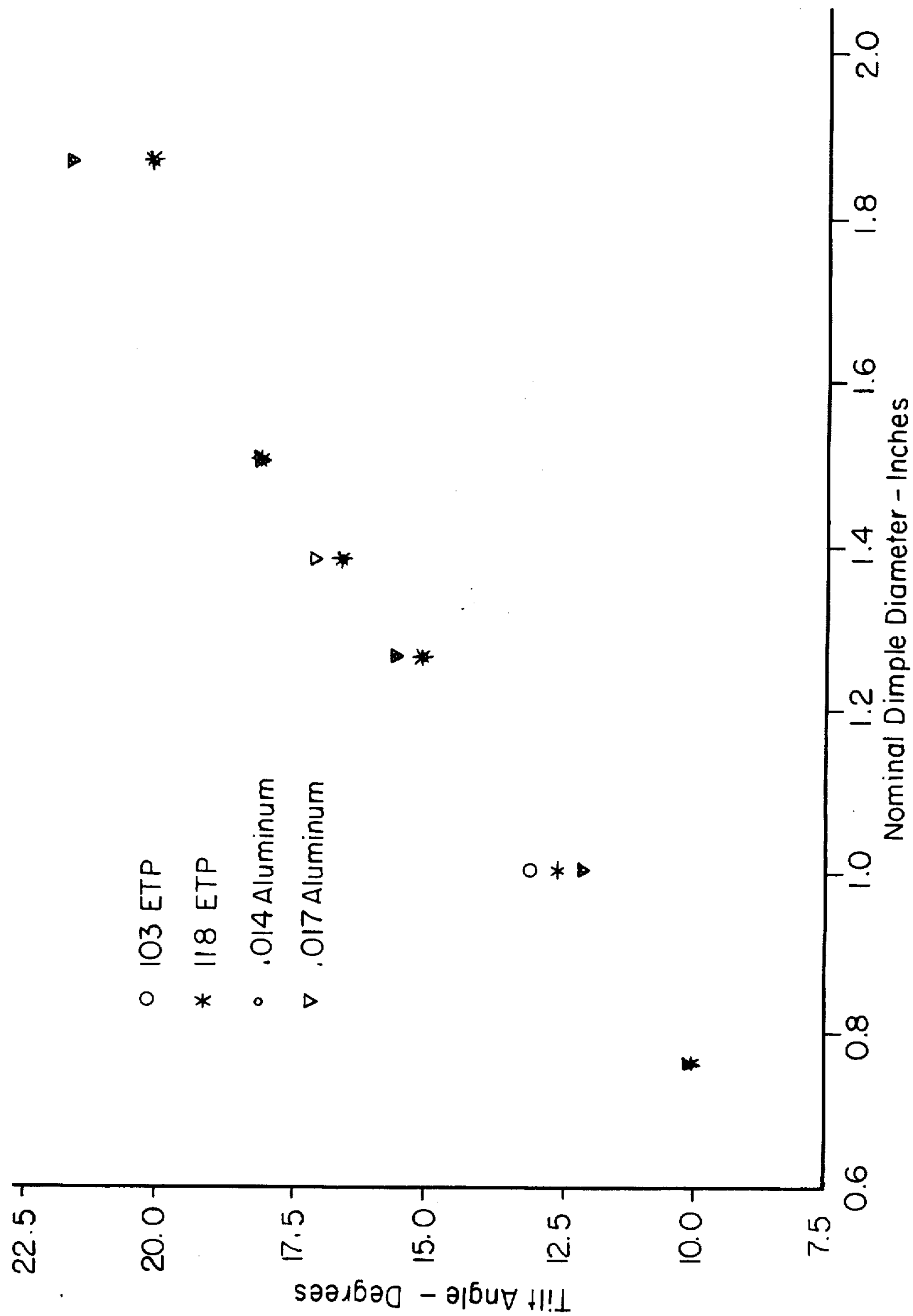

○ 103 ETP
∗ 118 ETP
∘ .014 Aluminum
▷ .017 Aluminum
Tilt Angle - Degrees
22.5
20.0
17.5
15.0
12.5
10.0
7.5
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Nominal Dimple Diameter - Inches

FIG. 17

FIG. 18

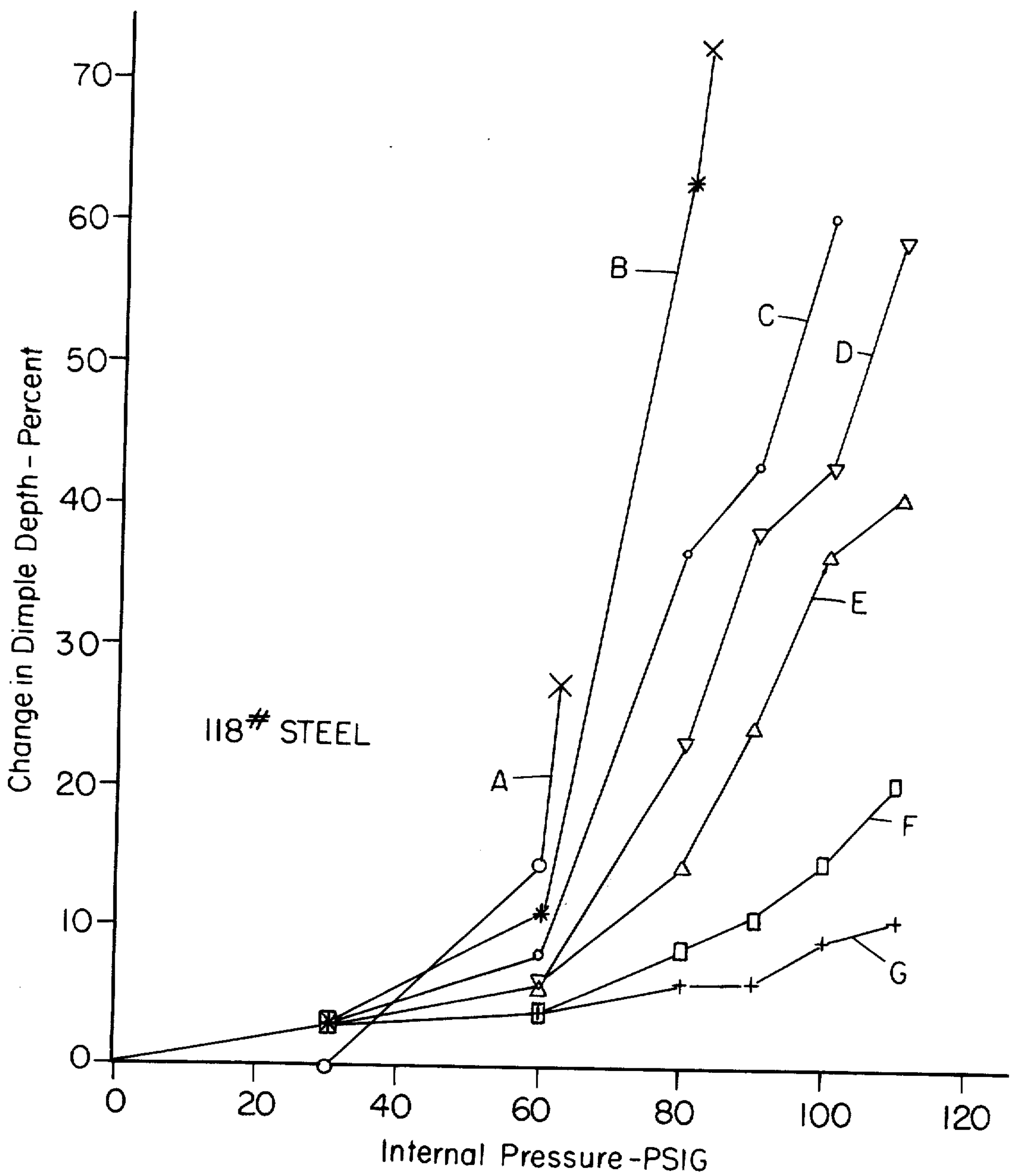

Change in Dimple Depth - Percent
0
10
20
30
40
50
60
70
118# STEEL
A
B
C
D
E
F
G
0
20
40
60
80
100
120
Internal Pressure-PSIG

FIG. 19

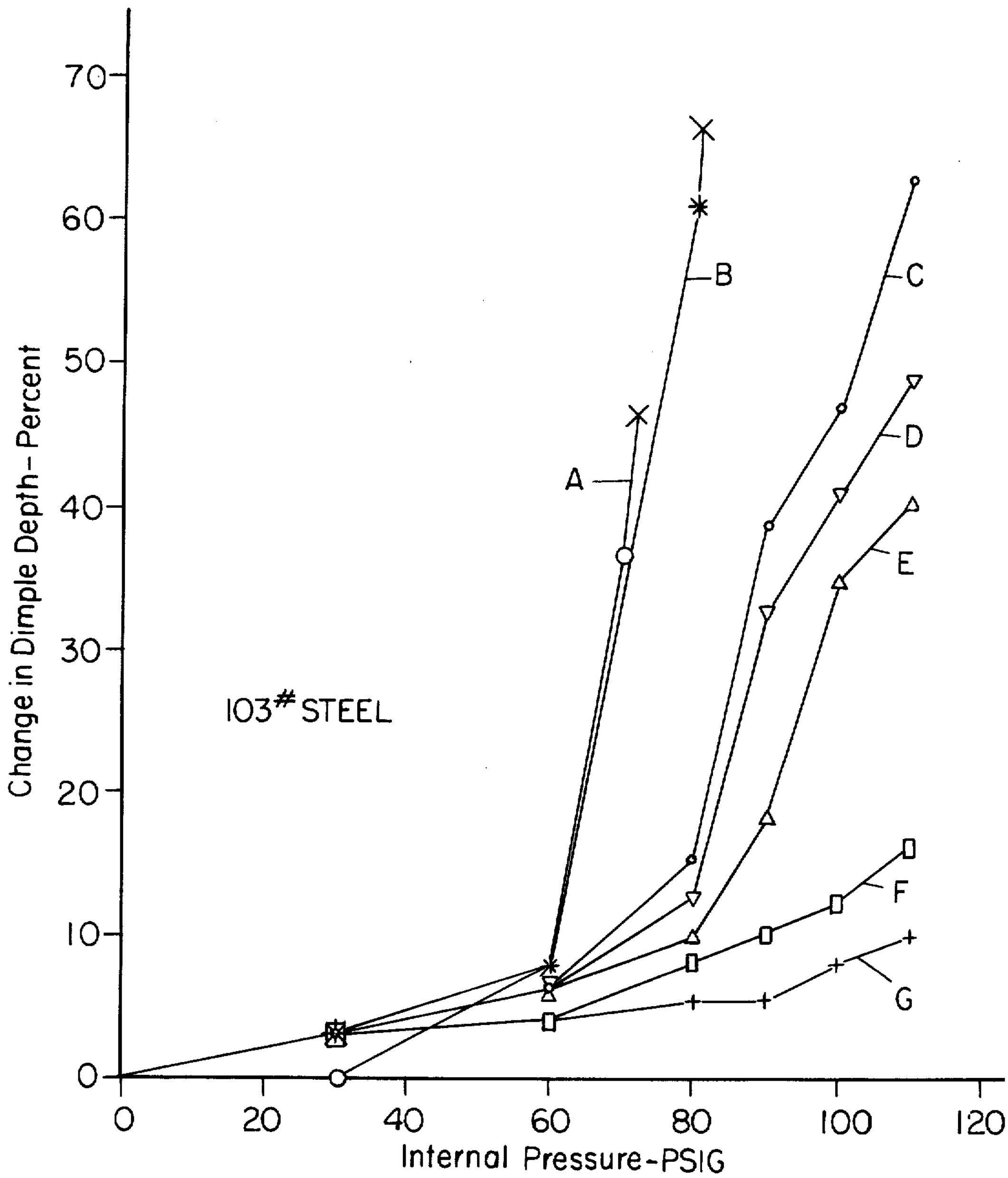

Change in Dimple Depth-Percent
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
Internal Pressure-PSIG
103# STEEL
A
B
C
D
E
F
G

FIG. 20

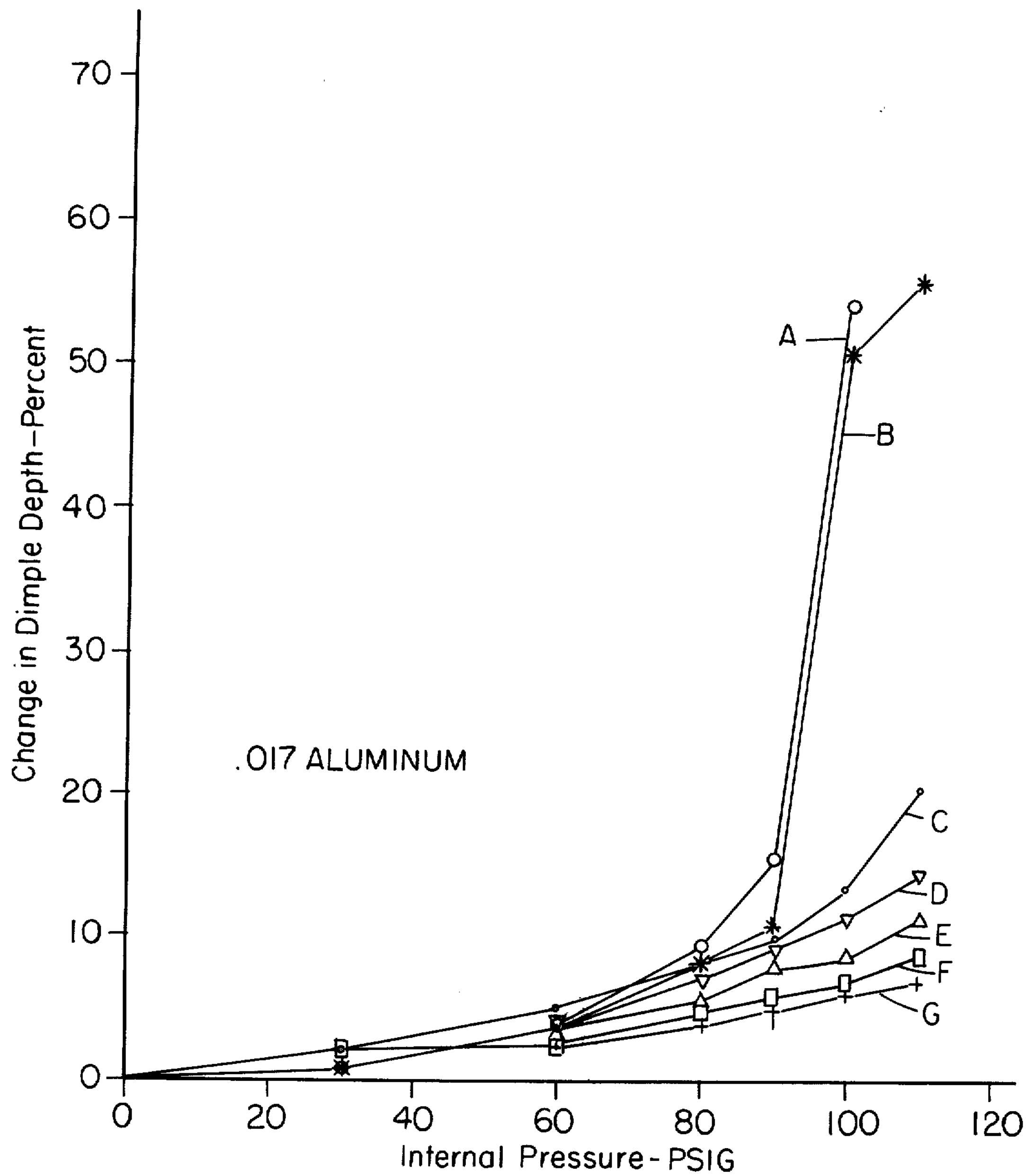
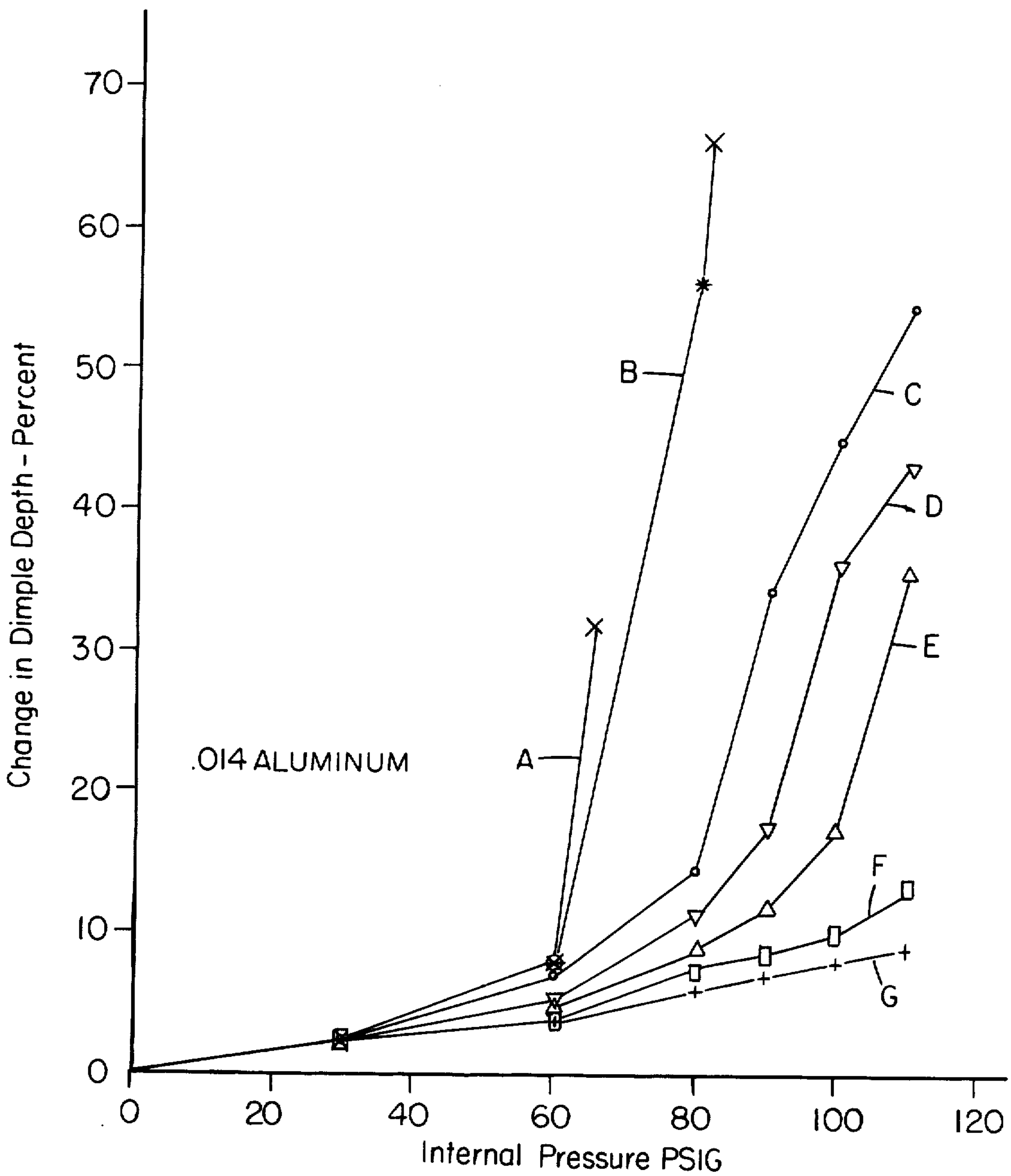

70
60
50
40
30
20
10
0
Change in Dimple Depth-Percent
.017 ALUMINUM
A
B
C
D
E
F
G
0
20
40
60
80
100
120
Internal Pressure-PSIG

FIG. 21


Change in Dimple Depth - Percent
70
60
50
40
30
20
10
0
.014 ALUMINUM
A
B
C
D
E
F
G
0
20
40
60
80
100
120
Internal Pressure PSIG

CONTAINER

This application is a continuation-in-part of my application Ser. No. 222,050, filed Jan. 31, 1972, now abandoned.

The present invention relates generally to an improved can or container construction which enhances the ability of the container to maintain an upright standing position when the container is subjected to internal pressure. More particularly, the present invention relates to an improved bottom wall construction for a container, in which the side and bottom walls of the container body are integrally formed, such that when the container is subjected to internal pressure the bottom wall is deformed in a uniform and predictable manner to provide a suitable base upon which to uprightly position the container.

At the present time conventional metallic containers may be formed from either two or three pieces of metallic material. In the three-piece container the components include a container body, which may be cylindrical in shape, and two suitable end closures secured to the ends of the container body. The components of the two-piece container include a container body having integral side and bottom walls and a separate end closure for closing the one open end of the container body. The two-piece container, being the type container with which the present invention is primarily concerned, presents numerous advantages over the conventional three-piece container with respect to manufacturing ease and aesthetic appeal. The container body of the two-piece container of the present invention is preferably made by drawing and ironing sheet metal and must, therefore, generally be constructed from a relatively ductile material. Drawing and ironing is a known can body forming process in which a sheet metal blank is first drawn into a relatively shallow cup and then the walls of the cup are ironed, which is to say thinned and extended to a height appropriate for the can. The bottom remains approximately as thick as the starting sheet. U.S. Pat. Nos. 2,412,813, 3,203,218 and 3,360,157 describe this process. If the container is made with a flat bottom wall, the internal pressures encountered with pressurized products such as beer or carbonated beverages cause the bottom wall of the container to deform outwardly into a convex configuration making it unstable when stored in an upright position unless the strength of the bottom wall is increased to withstand the pressure. Increasing the thickness of the starting sheet will provide a stronger bottom, but at the cost of more metal and higher shipping weights.

In order to increase the strength of bottom walls of container bodies having integral side and bottom walls, to thereby better withstand the pressures created by beer and carbonated beverages, it is well known to form the bottom wall of the container as an inwardly concave dome or depression which extends substantially throughout the bottom wall of the container. The increased strength provided by this fully domed bottom wall construction resists deformation of the bottom wall under increased internal pressure of the container with little change in the configuration of the bottom wall throughout the pressure range for which the container is designed. The container rests on the rim of the dome adjacent the cylindrical wall. A disadvantage of this fully domed construction is that upon elevation of the pressure beyond a critical point, the bottom wall of

the container suddenly pops out or everts. This is a catastrophic failure since the container suddenly becomes unserviceable due to its now swollen shape. In order to prevent such failure, the thickness of the bottom wall of the container must be sufficient to safely satisfy not only the pressure conditions anticipated, but also, because of the catastrophic nature of the eversion, must be able to resist pressures in excess of anticipated normal pressures. Another disadvantage of the full concave bottom wall construction is the difficulty of washing and protectively coating the interior of the container due to the high angle of the depression, which is in the nature of a countersink. Since the containers are washed and spray coated from their open ends, the bottom walls require a great deal of effort to be properly washed and coated. A still further disadvantage of the full concave bottom wall construction is the internal volume lost by virtue of the intrusion of the dome. More metal must be used to make the container large enough for its design capacity.

It is, therefore, an object of the present invention to provide a metal container having integral side and bottom walls wherein an improved bottom wall construction reduces or eliminates catastrophic eversion failure of the bottom wall, permits rather than resists expansion of the container under internal pressure while maintaining a stable support, and wherein minimum metal is required for a particular internal volume and for sufficient strength to safely withstand anticipated internal pressures.

The cylindrical container of the present invention is constructed with the integral bottom wall including a substantially flat panel section having a centrally disposed circular depression or dimple therein, the base area of the depression being no greater than approximately 60 percent and no less than approximately 15 percent of the total area of the bottom wall. This bottom wall construction provides a stable supporting base for the container when the container is subjected to internal pressure since the bottom is uniformly deformed by the internal pressure into a shape having a uniform circular ring upon which the container rests.

The present invention will be described and understood more readily when considered together with the accompanying drawings; in which;

FIG. 1 is a perspective view of the container body of the present invention shown in longitudinal section;

FIG. 2 is a perspective view of a slightly modified form of the container body of the present invention shown in longitudinal section;

FIG. 3 is a cross-sectional view of the lower portion of a prior art container body;

FIG. 4 is a cross-sectional view of the lower portion of another prior art container body;

FIG. 5 is an enlarged, cross-sectional detailed view of the lower portion of the container body of FIG. 1;

FIG. 6 is an enlarged, cross-sectional detailed view of the lower portion of the container body of FIG. 2;

FIGS. 7 through 11 are enlarged, cross-sectional detailed views of the lower portion of the container body of FIG. 1 showing the deformation of the bottom wall as the container is subjected to increasing internal pressures;

FIG. 12 is an enlarged cross-sectional detailed view of the lower portion of a container body of the present invention illustrating the manner of measurement of the ratio of the area of the depression to the total area of the bottom;

FIGS. 13–16 are graphic displays of data for different starting materials showing can height growth as a function of internal pressure for various depression sizes for containers according to the present invention,

FIG. 17 is a graphic display of data showing the stability of cans according to the present invention as a function of the size of the depression; and

FIGS. 18–21 are graphic displays of data for different starting materials showing percentage change in depression or dimple depth as a function of internal pressure for various depression sizes for containers according to the present invention.

Now referring to the drawings, there is shown in FIG. 1 a container body, generally designated **20**, which has been sectioned in half in order to better demonstrate the present invention. The container body includes a side wall **22** and a bottom wall **24** which are integrally formed. This type of container body, having integral side and bottom walls, is preferably formed of any suitable metallic material such as steel or aluminum by the known process of drawing and ironing.

As is shown in FIGS. **1** and **5**, the bottom wall **24** of container body **20** has a substantially flat annular panel section, generally designated **26**, having a centrally disposed circular depression or dimple **28** formed therein. The depression **28** may be of almost any suitable shape provided that the base edge or marginal intersection **30** of the depression with the annular panel **26** is circular so that the annular panel section **26** surrounds the depression. Although the depression **28** is shown in the drawings as having the shape of a segment of a sphere it may also be in the shape of a truncated cone, an ellipsoidal segment or a paraboloidal segment. At the periphery of the annular panel section **26** of FIGS. **1** and **5** there is provided a 45° angled transition edge, designated **32**, integrally interconnecting bottom wall **24** to side wall **22**.

As is shown in FIGS. **2** and **6**, which show a slightly modified form of the present invention, the 45° angled transition edge **32** is replaced by a radiused transition edge, designated **32***a*. The open end of container **20** is provided with a substantially horizontal flange, generally designated **34**, for the purpose of seaming an end closure (not shown) to the upper extremity of side wall **22**.

Prior two-piece containers for pressurized products such as beer or carbonated beverages have inwardly domed bottoms which extend to the cylindrical side walls. Many of those marketed employ a transition between the rim of the dome and the sidewall which usually is in the form of a radius which forms a rim on which the can sits. FIG. 3 is a depiction (not to scale) of one variant of this general construction in which the sidewalls **112** are turned inwardly toward the bottom to form a chamfered transition **114** which then merges with a radius **118** which forms the rim upon which the can sits. The dome **116** extends from rim **118** across the bottom **110** of the can. FIG. 4 is a depiction (not to scale) of a proposed construction shown in FIGS. 2 and 3 of U.S. Pat. No. 3,272,383 to Harvey. To more closely resemble a three-piece can for handling purposes, the proposed Harvey impact extruded two-piece can is provided with a bead **155** having the approximate external size and shape of the bottom chine of a conventional three-piece can. The bottom **152** extends beyond the cylindrical wall of the can to accommodate the bead **155**. Between the bead **155** and the inward

dome **150** is an annular margin **154** for supporting the container.

None of these prior bottom constructions is intended to expand in height in response to internal pressures. All are intended to resist expansion by confining the rim of the dome by the adjacent side walls or, in addition, by the thick walls and bottoms inherent in containers made by impact extrusion. The large domes of these prior art constructions are prone to sudden catastrophic eversion or pop-out when the internal pressure exceeds the structural strength of the bottom wall. The construction of the present invention avoids this catastrophic failure since the container of the present invention expands in a gradual predictable manner without eversion and continues to provide a stable support base throughout the pressure range for which it is designed and beyond.

FIGS. **7** through **11** demonstrate five stages in the continuous deformation through which the bottom wall **24** of a container body according to the present invention passes when subjected to increasing pressures. Throughout the stages depicted, the dimple or depression **28** remains concave in the inward direction thereby providing a suitable support base at the marginal circular intersection or edge **30** on which the container rests. The first stage, which is represented in FIG. **7**, depicts the configuration of the bottom wall **24** when the container is subjected to no pressure, the configuration in this figure is identical to that shown in FIG. **5**. The second stage, shown in FIG. **8**, depicts the configuration of the bottom wall when the container is subjected to an increased pressure over that of FIG. **7**. The height of the depression **28** in this second stage is slightly reduced or flattened and annular panel section **26** is slightly angled downwardly due to the applied pressure which causes the development of horizontal, outwardly directed forces near the edge **30** of the depression **28**. The deformation in this stage is still in the elastic range and therefore, the bottom wall **24** will return to its original shape as the pressure is released. The third stage is depicted in FIG. **9** wherein the pressure is increased over that of the second stage and where the material no longer remains in the elastic range. As can be readily seen, the height of the depression **28** is further reduced. FIG. **10** depicts the fourth stage through which the bottom wall **24** passes when subjected to a further increased pressure over that of the third stage. As can be seen, the panel section **26** and the angled transition edge **32** are deformed outwardly even further in this stage. In addition, the height of the depression **28** is further reduced as a result of the increased pressure. The fifth stage is depicted in FIG. **11** where the increased pressure further reduces the height of depression **28**. At this stage, there is a gradual and controlled further flattening of the depression **28** and the radius of intersection of edge **30** unrolls. This multiple stage controlled expansion is to be contrasted with the non-expansion followed by irregular bulging and catastrophic eversion encountered with the large domes of the prior art.

Proper selection of angle A (FIG. 7) the acute angle of the intersection of the annular panel **26** with the immediately adjacent portion of depression **28** will delay the deformation of stage four, depicted in FIG. **10**, until a more elevated pressure is reached. However, this will not prevent the occurrence of deflection of the annular panel section **26** into a generally conical shape as depicted in FIGS. **9** through **11**. The greater angle A is, the greater the resistance to outward expansion of bottom wall **24**. It has been found that angle A should be no less than about 43°. In order for the depression **28** to be formed with conventional dies, angle A should be made no greater than 90° and preferably about 60° in order to properly wash and spray coat the bottom wall of the container body.

Cans used for the packaging of pressurized products such as beer or carbonated beverages must be able to withstand internal pressures of about 95 psig. Beer is usually pasteurized in the filled and sealed can at a temperature and for a time which results in an internal pressure of 85 psig. To allow for errors of temperature or time, the minimum acceptable pressure capacity is 90 psig. Carbonated beverages vary according to the degree of carbonation. The highest degree of carbonation is encountered with club soda water which may produce an internal pressure at 100°F of approximately 95 psig. Since the same can body should be useful for all pressurized beverages, 95 psig is taken to be the minimum pressure capability.

Unlike the previous pressurized beverage containers, the construction of the container of the present invention is intended to expand in height as a result of internal pressure. When shipped from the beverage maker, filled cans according to the present invention are expanded from their unfilled configuration. Should the filled container encounter conditions which result in internal pressures in excess of the 95 psig for which they were designed, the containers will gradually and controllably expand further. They will not suddenly evert as do the fully or substantially fully domed containers of the prior art. This gradual intentional deformation of the bottom wall lessens the risk of explosion and maintains the container in a serviceable condition.

As the container of the present invention expands due to internal pressure, the marginal circular intersection or edge **30** of the depression or dimple **28** becomes the base upon which the container sits. The stability of the container depends upon the diameter of edge **30** in relation to the size of the can. The stability of the container is generally independent of the extent of its expansion or growth in height.

Stability of the container is important to the maker and to the consumer. Unstable cans interfere with the operation of the filling and packing machinery. Such machinery operates at high speed and cans which rock or wobble excessively can not be handled by the machinery. From the consumer's point of view, a can which tips, rocks or wobbles excessively when set down is an annoyance.

FIG. **12** shows the lower portion of a container according to the present invention similar to that of FIG. **6**. For convenience, the range of sizes of depressions or dimples is expressed as a percentage ratio of the area of the dimple to the area of the bottom of the container. The diameter *d* of the dimple or depression is measured between the centers **41** and **42** of the radius **30** which forms the transition or intersection between the exterior surface of the dimple and the exterior surface of the annular panel **26** of the bottom. Similarly, the diameter D of the bottom is measured between the centers **43** and **44** of the radius **32***a* which forms the transition between the outer diameter of the annular panel **26** and the side wall **22**. The ratio of the squares of these diameters (d^2/D^2) is equal to the percentage area ratio. This manner of measurement realistically determines the relative areas upon which pressure acts to deform the

container and eliminates the relatively rigid sidewall transition angle **32** or radius **32***a*. FIG. **7** shows the centers to be used for measurement of a bevelled or angled transition style of bottom using the same numbers as are used in FIG. **12**. By way of example, a 1⅜ inch nominal dimple diameter in a 210 (2 10/16 inch) diameter beer can having a radiused transition bottom as illustrated in FIG. **12** has an area ratio of 41.4 percent. The measured bottom diameter D between transition radii centers is 2.291 inch and the measured dimple diameter *d* between transition radii centers is 1.474 inch.

Referring again to FIGS. **1**, **2**, **5** and **6**, it has been found that the area of the base of the depression **28** must be between approximately 15 percent and 60 percent of the total area of bottom wall **24** in order to prevent the inward curvature of depression **28** from bulging outward under increased pressures.

DESCRIPTION OF A PREFERRED EMBODIMENT

A can according to one preferred embodiment is a 210 size 12-ounce can suitable for beer or carbonated beverages according to FIG. **2**. It is made by drawing and ironing 103 lb. T1 tin electroplated steel plate about 0.011 inch thick. The nominal outside diameter of the can body is 2 10/16 inch. The actual outside diameter is 2.556 inch. The actual height measured from the flat annulus **26** to the top of the lid flange **34** is 4.812 inch. The sidewalls are 0.0038 inch thick. The bottom wall is joined to the cylindrical sidewall by a transition radius of 0.125 inch to the inside. The diameter *d* of the dimple or depression measured to the centers of the transition radii is 1.475 inch for a nominal dimple diameter of 1.375. The dimple is approximately eliptical in section in that it is generated by a major radius of 1.500 and minor radii of 0.250. The dimple edge transition radius between the annular panel and the dimple is 0.050 to the inside. Angle A between the dimple and the annular panel is approximately 65°. The area ratio of dimple area to bottom area is 41.1 percent.

A can according to a second preferred embodiment is also a 210 size 12-ounce pressurized beverage can according to FIG. **2**. It is made by drawing and ironing 0.014 inch 3004 H-19 aluminum. The dimensions are identical to those of the steel can described above with the exceptions of an actual outside diameter of 2.559 inch, a sidewall thickness of 0.0048 inch, a dimple edge transition radius of 0.055 inch and a dimple diameter *d* of 1.485 inch for a nominal dimple diameter of 1.375 inch. The ratio of dimple area to bottom area is about 41.7 percent.

TEST RESULTS

Comparison tests of the deformations encountered with a flat bottom wall container, a full concave bottom wall container as depicted in FIG. **3**, and a container according to the present invention were made. The 12-ounce containers utilized in these tests were drawn and ironed from the same material, i.e. 0.013 inch, type L steel having a Rockwell Hardness of R 30 T scale 53±3 and a number 50 electrolytic tin plate. This material is called 118 pound plate. The dimensions of the tested containers were nominally 2 11/16 inches in diameter and nominally 4 13/16 inches in height. The container constructed according to the present invention (Table III) was provided with a 45° angled transition edge, a depression having the shape of a segment of a sphere of 1 inch radius and a height of approximately 0.260

inches, a nominal diameter of 1.25 inches, and an area ratio of 37.3%. The following tables compare measured deformations of the various bottom wall configurations at stated pressures:

TABLE I

Flat Bottom End - 45° Angled Transition Edge

Pressure (psig)	Deformation at Centerline	Permanent Deformation at Centerline	Stability Comments
0	0	0	Stable
40	.044	.028	Unstable
60	.057	.037	Unstable
80	.069	.047	Unstable
100	.080	.057	Unstable
120	.090	.068	Unstable

TABLE II

Full Concave Bottom Wall

Pressure (psig)	Deformation at Depression Center	Permanent Deformation at Depression Center	Deformation at edge of Depression	Permanent Deformation at edge of Depression	Stability Comments
0	0	0	0	0	Stable
40	.005	.001	.002	.0005	Stable
60	.010	.003	.005	.002	Stable
80	.021	.010	.011	.007	Stable
85	CATASTROPHIC FAILURE AT THIS PRESSURE				Unstable

TABLE III

Bottom Wall According to Present Invention

Pressure (psig)	Deformation at Depression Center	Permanent Deformation at Depression Center	Deformation at edge of Depression	Permanent Deformation at edge of Depression	Stability Comments
0	0	0	0	0	Stable
40	.038	.021	.022	.008	Stable
60	.061	.0415	.044	.026	Stable
80	.086	.067	.064	.049	Stable
100	.120	.100	.085	.0745	Stable
110	.150	.126	.105	.095	Stable

The results of these tests indicate first of all that the container having the flat bottom wall was unstable in the upright standing position due to bulging of the center portion of the bottom wall at pressures over approximately 20 psig, thereby making it totally unsuitable for pressurized products such as beer and carbonated beverages. The full concave bottom wall construction demonstrated a catastrophic failure, in other words a sudden eversion. popping out or bulging of the bottom wall, at pressures beyond 80 psig. However, at low pressures the deformation at the center of the full concave depression was substantially smaller, as indicated in the tables, than in the case of the other constructions. The depression in the bottom wall of the container of the present invention was found to remain in the inward direction without any substantial reduction in its cross-sectional area up to 110 psig. In addition stability tests indicated no rocking with the containers of the present invention and they were rated stable at all pressures specified.

As can be readily seen from studying the above tables, an internally pressurized container constructed in accordance with the present invention is able to maintain its stability in the upright standing position at

higher pressures than similar prior art containers. Furthermore, the thickness and strength of the bottom wall material may be diminished, relative to the other constructions, without correspondingly diminishing the stability of the container when it is positioned in the upright standing position. In addition to the above described container which is the 12-ounce size, other differently dimensioned containers have been produced and studied with similarly satisfactory results. One such container, having a 10-ounce capacity, was constructed with a 2 15/32 inch nominal diameter and a nominal height of 4 13/16 inches. The depression in the bottom wall of this container was identical to the depression in the bottom wall of the twelve ounce container of Table III. A 32-ounce container has also been constructed with nominal sizes of 3 7/16 inch diameter and 6 11/16 inch height. The bottom wall depression had a base diameter of approximately 1.66 inches and a height of approximately 0.44 inches and the shape of a segment of a sphere of one inch radius.

Data from extensive testing of cans made in accordance with the present invention are graphically displayed in FIGS. **13** through **21**. FIGS. **13–16** each show can height growth in inches plotted against internal pressure for various diameter dimples or depressions. FIG. **17** is a plot of tilt angles for various nominal dimple diameters. FIGS. **18–21** show the percentage change in dimple depth measured from rim **30** to the center of the dimple plotted against internal pressures for various nominal dimple diameters.

To generate the data of FIGS. **13–21**, cans were made of aluminum and of steel in two thicknesses for each material. The cans were formed by the drawing and ironing process. The thicker materials represent the current commercial minimum thicknesses for conventional fully domed bottom pressurized beverage cans. The thinner materials represent the minimum thickness for pressurized beverage cans now possible when made in accordance with the present invention.

All cans were made with a nominal outside diameter of 2 10/16 inch. This is a common 12-ounce size for beer or carbonated beverages and is frequently called a 210 can. The cans were made with spherical dimples which range from 0.750 inch to 1.852 inch in nominal diameter. Angle A between the dimple and the flat annulus was 43° for all cans. The steel cans were made from 118 pound and 103 pound tin electroplate stock of T1 temper having respective thicknesses of 0.013 inch and 0.011 inch. The sidewall thickness of the finished can bodies was 0.0038 inch. The aluminum cans were made from 0.017 inch and 0.014 inch 3004 H-19 drawing and ironing alloy and had a wall thickness of 0.0048 inch. The transition radius between the sidewall and the flat annulus of the bottom was approximately 0.125 inch.

The can bodies were subjected to internal air pressure in a testing fixture which permitted measuring the increase in height of the can at different pressures. The cans were subjected to increasing pressures up to 110 psi or until the can failed or obviously would hold no more pressure. Each height growth reading for an increased pressure was made at that increased pressure, but was preceded by a return to 30 psi in an effort to simulate the pressure cycling which a can filled with pressurized beverage might be expected to encounter in commerce. Height data for five identical cans was collected and the average of the five was plotted as a function of pressure. The curves of FIGS. **13–16** are fitted to those five-can average data points for each dimple size. Thus, dimple size is the parameter for the graphs.

The following tabulation relates nominal dimple diameters to the letter key used in FIGS. **13–16** and **18–21** to identify the curves and also relates nominal dimple diameter to the ratio of the dimple area to the bottom area as measured in the manner described in connection with FIG. **12**:

Curve Key Letter	Nominal Dimple Diameter	Area Ratio (d^2/D^2)
A	1.852"	72.5%
B	1.750	65.1
C	1.500	48.7
D	1.375	41.4
E	1.250	34.7
F	1.000	23.0
G	0.750	13.7

Comparison of FIGS. **13** through **16** shows that larger diameter dimples initially resist height expansion more than the smaller dimples. At a higher pressure the curves for the larger dimples increase in slope and cross over the curves for the smaller dimples. This indicates that the rate of height growth for the larger dimples rather suddenly exceeds the rate of height growth for the smaller dimples. Soon after this cross-over, the larger dimple cans either fail or diplay a very great rate of height growth indicating imminent failure. The actual increase in height is not particularly significant so long as it is not excessive. The can filling and handling machinery can be adjusted to accommodate high cans. A height increase of much more than one-quarter inch in a 12 ounce container would be excessive. Of more significance is the slope of the curve which represents the rate of increase in height. The steep slope typical of the larger dimples means a large change in height for a small change in pressure. This indicates that the can is near failure and also indicates that there will be noticeable differences in height among neighboring cans. Wide height variations among cans will lead to machine handling difficulties and is an aesthetic problem.

FIGS. **18–21** show the percentage ratio of the change in dimple depth to the original dimple depth. The data for these Figures was derived along with the can height growth data of FIGS. **13–16** from the same cans under test. Comparison of FIGS. **18–21** reveals that the larger diameter dimples above a 60 percent area ratio tended to roll out or flatten severely at pressures well below 95 psig.

As was stated before, 95 psig is taken to be the practical minimum pressure capability for pressurized product cans intended for beer and highly carbonated beverages. Consequently, cans which display a high rate of increase in height growth or dimple flattening or rollout at pressures below 95 psig are not acceptable.

It is clear from FIGS. **13** through **16** and **18** through **21** that curves A and B represent cans that failed below 95 psig or in the case of 0.017 aluminum represent cans with height growth rates or dimple depth change rates which are unacceptable before 95 psig is reached. Curve A is for cans having a nominal dimple diameter of 1.852 inches or an area ratio of 72.5 percent. Curve B is for cans having a nominal dimple diameter of 1.750 or an area ratio of 65.1 percent. Curves C through G represent cans which have nominal dimple diameters of 1.500 inches or less. These cans display acceptable height growth and dimple depth change characteristics. Translated into area ratios, cans above about 60 percent are unacceptable.

It should be noted that the data for the curves of FIGS. **13** through **16** represent can height growth at a particular pressure. The can will contract in height if the internal pressure decreases, but will not necessarily return to the height which that lower pressure would have caused initially because some permanent deformation occurs. By way of illustration, an aluminum beer can made from 0.014 stock with a nominal 1.375 inch dimple is represented by curve D of FIG. **16.** At the 85 psig internal pressure expected during pasteurization, the height growth is slightly more than the 0.125 inch which 85 psig caused. When later cooled, the internal pressure will drop to 30 psig or less. The permanent height growth will lie between the 0.050 inch which 30 psig originally caused and 0.125 inch, probably on the order of 0.100 inch. Thus, the data of FIGS. **13–16** is not representative of the increase in height present in the can when received by the consumer.

FIGS. **13–16** and **18–21** show that smaller dimples better withstand internal pressures above 60 or more psig.

FIG. **17** shows that stability or resistance to tipping, rocking or wobbling decreases as dimple size is reduced. Although a can with a small dimple may be excellent from a pressure standpoint, it may be unacceptable from a stability standpoint. The data points plotted on FIG. **17** were obtained by placing filled, sealed and pasteurized 12 ounce 210 cans of simulated beer on a horizontal platform and slowly tilting the platform until the can started to tip. The angle of the platform and the nominal dimple size were noted and the average of several cans was used to produce the data points. Cans having a nominal dimple diameter of 0.750 are considered to be unstable because they rock or wobble disconcertingly when set upon a table and cause problems on high speed filling and handling equipment. Cans having nominal dimple diameters larger than 0.750 are considered to be adequately stable for processers and consumers. The larger dimple cans approach the stability of a fully domed bottom can. Translated into area ratios, those cans having an area ratio above about 15 percent are adequately stable.

As a part of this test program cans of the same description as above were made of 90 pound steel plate 0.010 inch thick and of 0.010 inch aluminum. Only a few of the steel cans and none of the aluminum cans were capable of withstanding 95 psig internal pressure. Metal this thin is not appropriate for pressurized beverage cans.

The various testing reported herein verifies that fully domed 210 or 211 12-ounce beer cans are prone to failure at pressures as low as 85 psig unless made of materials stronger than 118 pound T1 steel plate or than 0.017 inch 3004 H19 aluminum. However, cans according to the present invention can be made from 103 pound steel plate or from 0.014 inch aluminum. The enabled use of thinner metal coupled with the smaller volume loss occasioned by the dimple as compared with the full dome represent very substantial metal savings. Further, the thinner can of the present invention is able to withstand the 95 psig pressure required for containers of highly carbonated beverages so that the same can body can be used for either beer or beverages at all carbonation levels. Fully domed 0.017 inch aluminum 12-ounce 210 drawn and ironed cans weigh approximately 34 pounds per thousand. Aluminum cans according to the present invention are made of 0.014 inch stock and weigh approximately 28 pounds per thousand. The prior art aluminum cans are over 21 percent heavier. Similarly, fully domed 118 pound steel 12-ounce 210 drawn and ironed cans weigh about 76.9 pounds per thousand whereas 103 pound steel cans according to the present invention weigh about 64.4 pounds per thousand. The prior art steel cans are over 19 percent heavier. Since metal is a major factor in can cost, metal savings of this degree are significant. Thus, the present invention not only provides a can which comfortably withstands significantly higher internal pressures than the fully domed can of the prior art and reduces the chance of explosion of cans exposed to conditions which generate pressures in excess of the design pressure, but also effects a substantial reduction in can cost.

What is claimed is:

1. An eversion resistant, generally cylindrical drawn metal container having therein a product under pressure, said container including a generally cylindrical body having integral side and bottom walls, said bottom wall comprising a central inwardly domed depression surrounded by an annular panel, said depression having a marginal circular intersection with said annular panel, at least said annular panel having been outwardly distended by pressure of said product to permanently change the shape of the bottom wall such that said circular intersection becomes the outermost extent of the bottom wall, said annular panel being inclined into a generally conical shape and forming an obtuse angle with said sidewall, the percentage ratio of the area determined by the radius of said circular intersection to the area determined by the outer radius of said annular panel being in the range of from approximately 15 percent to approximately 60 percent, said circular intersection alone providing a stable base upon which the container rests in an upright position.

2. The container of claim **1** wherein the nominal outside diameter of the sidewall is 2 11/16 inches, wherein the nominal diameter of the depression is 1.25 inch, and the container is made from 118 pound electrolytically tin plated steel.

3. The container of claim **1** wherein said depression is concave and remains concave at a pressure of 95 psig.

4. The container of claim **1** wherein the bottom wall comprises 3004 H-19 aluminum and has a thickness greater than 0.010 inch and less than 0.017 inch.

5. The container of claim **1** wherein the bottom wall comprises T-1 temper, tin-electroplated steel and has a thickness greater than 0.010 and less than 0.013 inch.

6. The container of claim **1** wherein the depression is generally spherical in shape.

7. An eversion resistant, generally cylindrical container drawn from metal selected from the group consisting of less than 0.013 inch thick steel and less than 0.017 inch thick aluminum alloy capable of withstanding an internal pressure and having therein a product under pressure, said container including a generally cylindrical body having integral side and bottom walls, said bottom wall comprising a central inwardly domed depression surrounded by an annular panel, said depression having a marginal circular intersection with said annular panel, at least said annular panel having been outwardly distended by pressure of said product to permanenlty change the shape of the bottom wall such that said circular intersection becomes the outermost extent of the bottom wall, said annular panel being inclined into a generally conical shape and forming an obtuse angle with said sidewall, the percentage ratio of the area determined by the radius of said circular intersection to the area determined by the outer radius of said annular panel being in the range of from approximately 15 percent to approximately 60 percent, said circular intersection alone providing a stable base upon which the container rests in an upright position.

8. An eversion resistant, generally cylindrical container drawn from metal selected from the group consisting of less than 0.013 inch thick steel and less than 0.017 inch thick aluminum alloy capable of withstanding an internal pressure of 95 psig and having therein a beverage under pressure, said container including a generally cylindrical body having integral side and bottom walls, said bottom wall comprising a central inwardly domed depression surrounded by an annular panel, said depression having a marginal circular intersection with said annular panel, at least said annular panel having been outwardly distinded by pressure of said beverage to permanently change the shape of the bottom wall such that said circular intersection becomes the outermost extent of the bottom wall, said annular panel being inclined into a generally conical shape and forming an obtuse angle with said sidewall, the percentage ratio of the area determined by the radius of said circular intersection to the area determined by the outer radius of said annular panel being in the range of from approximately 15 percent to approximately 60 percent, said circular intersection alone providing a stable base upon which the container rests in an upright position.

9. The container body of claim **8** wherein the percentage ratio of areas is about 50 percent.

10. The container body of claim **8** wherein the percentage ratio of areas is about 40 percent.

11. The container body of claim 8 wherein the percentage ratio of areas is about 35 percent.

12. The container body of claim 8 wherein the percentage ratio of areas is about 30 percent.

13. The container body of claim 8 wherein the percentage ratio of areas is about 25 percent.

14. The container of claim 8 wherein the nominal outside diameter of the sidewall is 2 10/16 inches and wherein the nominal diameter of the depression is in the range of from about 1 inch to about 1.5 inches.

15. The container of claim 8 wherein the nominal outside diameter of the sidewall is 2 10/16 inches and the area ratio is about 40 percent.

16. The container of claim 8 wherein the body is a drawn and ironed container body.

17. The container of claim 2 wherein said body comprises tin-electroplated steel.

18. The container of claim 17 wherein said steel is 103 pound plate before being drawn and ironed.

19. The container of claim 16 wherein said body comprises aluminum.

20. The container of claim 19 wherein said aluminum is 0.014 inch in thickness before being drawn and ironed.

21. An eversion resistant bottom wall construction for a substantially rigid drawn metallic cylindrically shaped pressurized beverage container subjected to internal pressure and having integral side and bottom walls of thin metal, said bottom wall comprising:

an annular panel integrally connected to the side wall of said container;

an inwardly extending depression centrally disposed in said panel, said depression merging peripherally with said panel in a circular base edge, the supplement of the angle formed therebetween being no less than 43°;

the projected area of said depression constituting no less than 15 percent and no more than 60% of the total projected area of said bottom wall;

at least said annular panel having been outwardly distended by pressure of said beverage to permanently change the shape of the bottom wall such that said circular base edge becomes the outermost extent of the bottom wall, said depression remaining inwardly extending from said annular panel, said circular base edge alone providing a stable support for said container.

22. An eversion resistant bottom wall construction for a substantially rigid cylindrically shaped beverage container subjected to internal pressure, said bottom wall being of metal selected from the group consisting of less than 0.013 inch thick steel and less than 0.017 inch thick aluminum alloy, said bottom wall comprising:

an annular panel integrally connected to the side wall of said container;

an inwardly extending depression centrally disposed in said panel, said depression merging peripherally with said panel in a circular base edge;

the projected area of said depression constituting no less than 15 percent and no more than 60 percent of the total projected area of said bottom wall;

at least said annular panel having been outwardly distended by pressure of said beverage to permanently change the shape of the bottom wall such that said circular base edge becomes the outermost extent of the bottom wall, said depression remaining inwardly extending from said annular panel, said circular base edge alone providing a stable support for said container.

23. The eversion resistant bottom wall construction for a cylindrically shaped container as defined in claim 22 wherein the supplement of the angle formed by the peripheral merging of said depression with said annular flat panel is no less than 43° and no greater than 90°.

24. An eversion resistant, generally cylindrical metal container having therein a product under pressure, said container including a body drawn and ironed from relatively thin metal sheet selected from the group consisting of less than 0.013 inch thick steel and less than 0.017 inch thick aluminum alloy, said body having a generally cylindrical sidewall having a transition edge, said transition edge being integral with a bottom wall, said bottom wall comprising a central inwardly concave dome surrounded by an annular panel extending to said transition edge, said dome having a marginal circular intersection with said panel, at least said annular panel having been outwardly distended by pressure of said product to permanently change the shape of the bottom wall such that said circular intersection becomes the outermost extent of the bottom wall said intersection being in the form of a radius between said dome and said panel, said intersection alone providing a stable base upon which the container rests in an upright position, the percentage ratio of the area of the circle encompassed by said intersection to the area of the circle encompassed by the transition edge is in the range of from about 15 percent to about 60 percent.

25. The container of cla'm 24 wherein the transition edge is an inwardly bevelled section of the sidewall.

26. The container of claim 24 wherein the transition edge is a radius.

27. An eversion resistant bottom wall construction for a substantially rigid drawn metallic cylindrically shaped container having therein a beverage under pressure and having integral side and bottom walls of thin metal, said bottom wall comprising:

an annular panel integrally connected to the side wall of said container;

an inwardly extending depression centrally disposed in said panel, said depression merging peripherally with said panel in an angled annular base edge, the angle formed thereby being no less than about 43°;

the projected area of said depression constituting no less than 15 percent and no more than 60 percent of the total projected area of said bottom wall;

at least said annular panel having been outwardly distended by pressure of said beverage to permanently change the shape of the bottom wall such that said annular base edge becomes the outermost extent of the bottom wall, said depression remaining inwardly extending from said annular panel, said annular base edge alone providing a stable support for said container.

28. An eversion resistant bottom wall construction for a substantially rigid cylindrically shaped container having therein a beverage under pressure and having integral side and bottom walls drawn and ironed from sheet metal selected from the group consisting of less than 0.013 inch steel and less than 0.017 inch aluminum alloy, said bottom wall comprising:

an annular panel integrally connected to the side wall of said container;

an inwardly extending depression centrally disposed in said panel, said depression merging peripherally with said panel in an angled annular base edge, the angle formed thereby being about 43°;

the projected area of said depression constituting no less than 15 percent and no more than 60 percent of the total projected area of said bottom wall;

at least said annular panel having been outwardly distended by pressure of said beverage to permanently change the shape of the bottom wall such that said annular base edge becomes the outermost extent of the bottom wall, said depression remaining inwardly extending from said annular panel, said annular base edge alone providing a stable support for said container.

29. The construction of claim **28** wherein the bottom wall comprises 3004 H-19 aluminum and has a thickness greater than 0.010 inch and less than 0.017 inch.

30. The construction of claim **28** wherein the bottom wall comprises T-1 temper, tin-electroplated steel and has a thickness greater than 0.010 inch and less than 0.013 inch.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,904,069

DATED : September 9, 1975

INVENTOR(S) : Aram Hartoun Toukmanian

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 17, line 1, "2" should be -- 16 -- .

Signed and Sealed this

sixteenth Day of *December 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks